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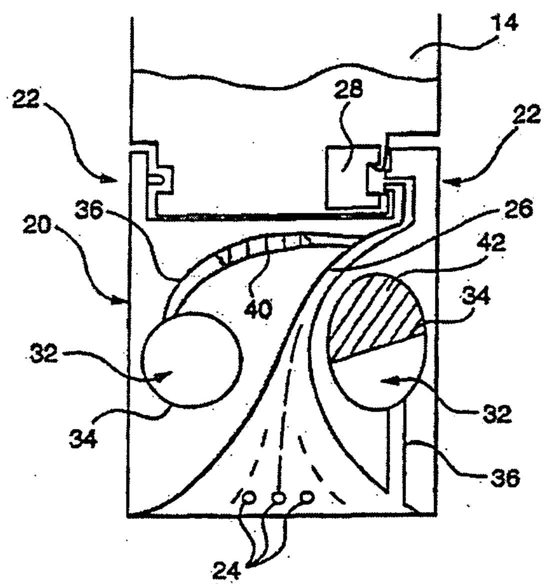
(54) Title: HORN LOADED MICROPHONE WITH HELMHOLTZ RESONATOR ATTENUATOR

(57) Abstract

Disclosed is a method and apparatus for attenuating unwanted frequencies in an acoustical waveguide (26) of a mobile telephone microphone system. One or more Helmholtz resonators (32) is connected to the acoustical waveguide. The Helmholtz resonator's geometry is set to resonate at a frequency to be attenuated. Because the resonator takes that particular tuned frequency and absorbs energy therefrom (in order for the resonator to resonate), the energy level of that frequency is reduced, especially with respect to the acoustic energy of the spectrum transmitted along the waveguide towards the mobile telephone microphone.



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HORN LOADED MICROPHONE WITH HELMHOLTZ RESONATOR ATTENUATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to microphones and specifically to microphones used in mobile telephones in which it is desirable to limit the bandwidth of signals transmitted.

2. Description of the Prior Art

Cellular telephones and other communication devices are continually being reduced in physical size making them more convenient to use and providing extreme ease of operation. One challenge with making such devices smaller is the proper location of a microphone near the user's mouth to easily pick up acoustic vibrations of speech. A well-known class of cellular phones has been developed known as "flip phones" in which a panel or structure is normally in a folded position but when the telephone is in use, is "flipped" out into an open position. The open position locates a microphone acoustically in close proximity to the user's mouth. However, the electrical connections to this microphone are capable of wear over numerous opening and closing cycles and it has become desirable not to include the microphone in the "flip" portion of the phone.

It is now known to mount the microphone in the phone body and provide an acoustic waveguide for channeling sound waves from the end of the "flip" to the microphone's location. A preferred embodiment of such a microphone is shown in U.S. Serial No. 08/642,746 entitled "Acoustic Horn For Use In Cellular Flip Phones", filed by the present inventor on May 3, 1996, the subject thereof incorporated herein by reference. This then eliminates the need for locating a bulky microphone or the electrical connections thereto in the flip, thus simplifying the construction.

The waveguide itself is typically constructed by creating a hollowed out passage inside the phone body and inside the flip. Standard materials are used (generally plastics) and generally there is no need to dampen the phone body or the flip. "Condenser" microphones are almost exclusively used. In the design and construction of the waveguide, there are restrictions on size, placement, esthetics, etc. The holes which allow the sound into the acoustic waveguide

may be slots, a single hole or a plurality of holes, but generally have a minor effect on the performance of the system.

The transmit frequency response of most cellular telephones is between 200 and 3000 hertz. Normally, after the acoustic signal is transduced into an electronic signal by the microphone, the signal is electronically filtered to limit it to the transmit frequency band. However, as the size of cellular telephones becomes ever more limited, the space on the printed circuit board and electronic chips also becomes smaller and it is desirable to reduce electronic filtering of the voice signal if at all possible.

SUMMARY OF THE INVENTION

It is an object of the present invention to reduce the need for electronic filtering of the voice signal from the microphone in a mobil telephone.

It is a further object of the present invention to improve the signal to noise ratio of the microphone in a mobile telephone.

It is a further object of the present invention to reduce the size of a cellular phone by reducing the need for an electronic filter to be located in the cellular telephone.

The above and other objects are achieved in accordance with the present invention by the provision of one or more Helmholtz resonators associated with a waveguide which serves to provide acoustic energy from a cellular telephone flip to the microphone. The Helmholtz resonator is tuned to the desirable frequency (which is to be filtered), and the acoustic energy at that frequency is used to stimulate resonance in the Helmholtz resonator thereby taking away energy at the desired attenuation frequency from the acoustical signal which is passed along the waveguide to the microphone.

BRIEF DESCRIPTION OF THE DRAWINGS

The above, as well as other advantages and features of this invention, will be more completely understood and appreciated by review of presently preferred exemplary embodiments taken in conjunction with the accompanying drawings, of which:

Fig. 1 is a perspective view of a mobile telephone in accordance with the present invention;

Fig. 2 is a partial cross-sectional view of the flip portion of the mobile telephone of Fig. 1;

Fig. 3 is a perspective view of the flip portion of the mobile telephone of Fig. 1;

Fig. 4 is a side cross-sectional view of a portion of the phone body and the flip portion of the mobile telephone of Fig. 1; and

Fig. 5 is a schematic diagram showing the pertinent dimensions of a Helmholtz resonator.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In discussion of the preferred embodiments illustrated in the accompanying drawings, similar numbering will be used for similar structures among these several views.

In Figure 1, the method and apparatus according to the present invention is disclosed and includes a mobile telephone 10 having an antenna 12 connected to a body 14 having an alphanumeric display 16. Keypad 18 controls the functions of the mobile telephone. Phone body 14 is connected to the flip 20 by hinges 22 which permit the flip to be folded up into a closed position adjacent the phone body when the phone is not in use and to be folded down as shown in Fig. 1 so that the phone can be used. It will be seen that there are a plurality of sound inlet holes 24 along the lower portion of the flip which serve to acoustically interconnect the user's voice with the microphone located in the phone body.

The interrelationship between the sound holes and the microphone can perhaps be better understood by reference to Fig. 2 which is a sectional view of the flip portion of the cellular phone in the plane of the flip. The acoustic waveguide 26 extends from the sound holes 24 to the vicinity of microphone 28 which is located in the phone body 14. In this preferred embodiment, the acoustic waveguide 26 passes concentrically through hinge 22 so as to pass sound to the microphone 28 regardless of the position of the flip 24. Other embodiments of the acoustic waveguide however pass acoustic energy to the microphone only when the flip is open (only when the flip is open, is a port from the acoustic waveguide in operable conjunction with a port on the phone body which is, in turn, connected to the microphone). In use, acoustic energy from the user's voice passes through sound holes 24 (which may be holes or a slot 30 as shown in Fig. 4) or any other aperture or means for conveying acoustic energy from the user's voice into the acoustic waveguide.

Also seen in Fig. 2 are the location of Helmholtz resonators 32. Each Helmholtz resonator is comprised of an enclosure 34 having a closed volume and a small opening

connected through tube 36 to the acoustic waveguide 26. While the resonators may be of similar or idnetical size, they can also be of different size so as to attenuate diffeent frequencies. As will be seen, the geometry of the Helmholtz resonator lends itself to utilization in the flip portion of a mobile telephone and can effectively "tune out" or attenuate undesirable frequencies and prevent their passage to microphone 28 thereby reducing the need for subsequent electronic filtering of these frequencies.

Fig. 3 is a perspective view of an embodiment of the flip in which a slot 30 captures acoustic energy from the user's voice and transmits it internally through hinge 22 to provide the acoustic energy at microphone 28 by way of aperture 38. Holes 24, slot 30, and other similar devices comprise a means for conveying acoustic energy of the user's voice into the flip and channeling such energy down acoustic waveguide 26 ultimately to microphone 28. A side cross-sectional view of the flip in Fig. 3 clearly illustrates the acoustic waveguide path from slot 30 to aperture 38.

A Helmholtz resonator comprises an enclosure having a small opening with a tube having dimensions such that the enclosure resonates at a single frequency determined by the geometry of the resonator. A soda bottle is a well-known example of a Helmholtz resonator. The contained volume of air can be likened to a spring and the column of air can be considered a weight. When an outside force (blowing into the bottle) acts upon the system, the combination of the springiness of the trapped air with the mass of the column of air will cause the system to oscillate at a particular frequency. Of course, energy from the person blowing across the bottle top is required to excite the system into resonance.

If, as is disclosed in Fig. 2, a Helmholtz resonator is connected to an acoustic waveguide, when an acoustic signal, which is at approximately the same frequency as the resonator, passes along the waveguide, the resonator will resonate and, by resonating, will take a certain portion of that energy out of the acoustic waveguide. In other words, the Helmholtz resonator will take out of the acoustic waveguide, the particular frequency of resonance. By controlling the dimensions of the components of the resonator and/or utilizing a damping material in and around the resonator, the attenuation of a desired frequency in the acoustic waveguide can be easily accomplished. Damping materials could be employed in the tube portion (as shown by damping material 40) and/or in the resonating volume portion (as shown

by damping material 42) of the resonator and could include polyester fiber, wool, open-celled foam, felt, or other material including plastic.

As discussed above, the electronically transmitted component of the acoustic energy is within the range of 200 to 3,000 hertz and thus it is desirable to acoustically attenuate any signal above 3,000 hertz or below 200 hertz. Although the Helmholtz resonator could be used to attenuate the above 3,000 hertz signal as well, it is primarily employed to reduce the response at frequencies below 200 hertz, because other aspects of the acoustic waveguide (such as bends in the acoustic path) attenuate the higher frequencies. However, a waveguide design could have other frequency anomolies, especially around the 3 kHz frequency where the use of such a resonator may be helpful.

The geometry of the resonator is shown in Fig. 5 in which "W" is the width or diameter and "h" is the height of the resonating volume. "L" is the length and "d" is the diameter of the tube. The resonant frequency of a Helmholtz resonator is given as:

$$f_0 = \frac{Cd}{2\pi W} x \sqrt{1/h} (L + .75d)$$

where C is the speed of sound in air. It will be seen that with an embodiment in which the length of the tube is between 30 and 60 millimeters, the diameter of the tube is .5 mm, the resonating volume has a width of 25 mm and a height of 1 mm, the resonant frequency would be between 140 hertz (length of 60 mm) and 200 hertz (length of 30 mm). Accordingly, resonators of such dimensions in association with the acoustic waveguide 26 would absorb those particular frequencies from acoustic energy traveling in the waveguide.

The location of the junction between the tube 36 and the acoustic waveguide 26 can affect the amount of the acoustic damping. For instance, the location of the junction near the narrowest part of the acoustic waveguide 26 will maximize the effect whereas placement near the wider portion of the acoustice waveguide will minimize the effect. While the use of the Helmholtz resonator will also increase the signal to noise ratio of the microphone system, it can also reduce or eliminate certain types of otherwise necessary electronic filtering by acoustically filtering the input. For example a flatter response would make the job of any echo cancelling circuitry easier and potentially less complicated.

While it is desirable to design the waveguide itself to avoid resonance at any acoustic frequency of interest (certainly over the 200 hertz to 3,000 hertz operational band), annoying resonances could also be removed by providing a Helmholtz resonator tuned to that particular frequency. Normally, however, one or more Helmholtz resonators would be utilized to attenuate the lower frequencies (below 200 hertz) thereby reducing the need for an electronic filtering circuit located in the phone body. Additionally, a resonator could be tuned to a pass band of between 200-3000 Hz.

Depending upon the specific application, it will be readily apparent to those of ordinary skill in the art that numerous modifications of the present invention would be appropriate. Given the space available in the flip, both low and high frequency attenuators could be located at various positions along the acoustic waveguide. While the preferred embodiment illustrates a decreasing cross-sectional area waveguide, i.e., a horn-shaped waveguide, different forms of waveguides could also be utilized which could then be modified by use of one or more Helmholtz resonators.

Additionally, while the Helmholtz resonator is shown as comprising a circular volume having a constant height, different forms and variations of the Helmholtz resonator could be utilized, for example, different shaped cavities, different connectors, or perhaps even multiple connectors connecting the same resonator to the acoustical waveguide at different points such that, because they are out of phase, they will tend to attenuate the undesirable frequencies to a greater extent.

Accordingly, the present invention is limited only by the claims appended hereto and, in the broadest sense, is not limited to the specific examples included in this application.

WHAT IS CLAIMED IS:

1. A system for converting acoustic energy into electrical energy, said microphone comprising:

an acoustic energy to electrical energy transducer;

an acoustic passageway for conducting acoustic energy to said transducer; and

at least one acoustic attenuator associated with said passageway for attenuating at least one frequency of acoustic energy along said passageway.

2. The system according to claim 1, wherein said acoustic attenuator is a Helmholtz resonator.

3. The system according to claim 1, wherein said at least one frequency of acoustic energy is within the range of less than 200 Hz.

4. The system according to claim 1, wherein said at least one frequency of acoustic energy is within the range of greater than 3 KHz.

5. The system according to claim 2, wherein said at least one frequency of acoustic energy is within the range of less than 200 Hz.

6. The system according to claim 2, wherein said at least one frequency of acoustic energy is within the range of greater than 3 KHz.

7. The system according to claim 2, wherein said Helmholtz resonator comprises:

a resonator having a diameter W and a height h; and

a connection tube having a length L connecting said resonator to said acoustic passageway.

8. The system according to claim 7, wherein said resonator is cylindrical in shape and said diameter d is approximately 25 mm and said height h is approximately 1 mm.

9. The system according to claim 7, wherein said connection tube has a diameter of 0.5 mm and a length L of between about 30 and about 60 mm.

10. The system according to claim 9, wherein said resonator is cylindrical in shape and said diameter W is approximately 25 mm and said height h is approximately 1 mm.

11. The system according to claim 1, wherein said microphone is a mobile telephone microphone.

12. The system according to claim 1, further including a damping material located in said acoustic passageway.

13. The system according to claim 1, further including a damping material located in said acoustic attenuator.

14. The system according to claim 7, wherein the dimensions of the acoustic passageway and the Helmholtz resonator meet the requirements of:

$$f_0 = \frac{Cd}{2\pi W} x \sqrt{1/h}\,(L \div .75d)$$

where, f_0 is the at least one frequency, C is the speed of sound in air, the Helmholtz resonator having a width W and a height h, the connection tube having a length L and a diameter d connecting said resonator to said acoustic passageway.

15. A method of attenuating at least one acoustic frequency in a microphone, said microphone includes an acoustic energy to electrical energy transducer, said method comprising the steps of:

providing a passageway for conducting said acoustic energy to said transducer; and

connecting at least one resonator to said passageway where said resonator is resonant at said at least one acoustic frequency.

16. The method according to claim 15, wherein said microphone is a mobile telephone microphone.

17. The method according to claim 15, wherein said connecting step includes providing a Helmholtz resonator.

18. The method according to claim 17, wherein said Helmholtz providing step includes providing the dimensions of the acoustic passageway and the Helmholtz resonator meeting the requirements of:

$$f_0 = \frac{Cd}{2\pi W} x \sqrt{1/h} (L + .75d)$$

where, f_0 is the at least one frequency, C is the speed of sound in air, the Helmholtz resonator having a width W and a height h, the connection tube having a length L and a diameter d connecting said resonator to said acoustic passageway.

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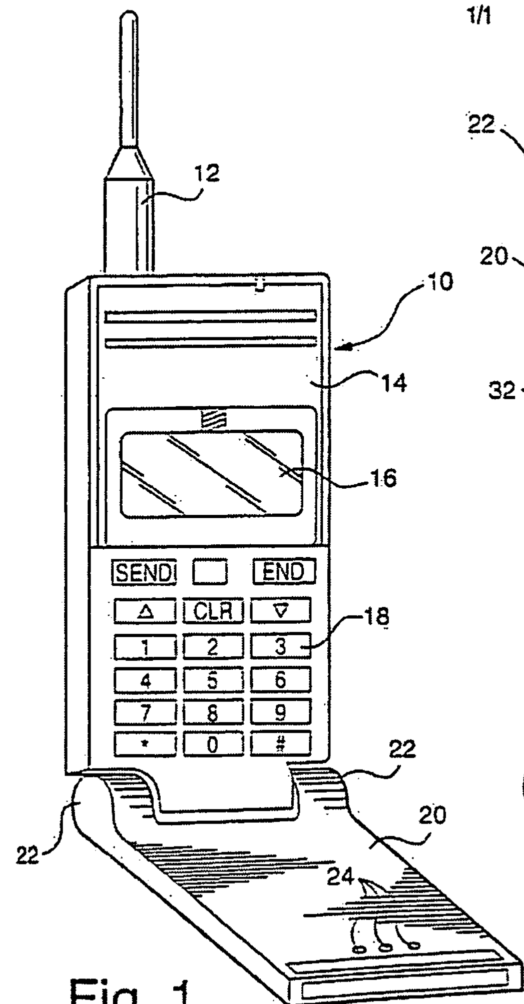

Fig. 1

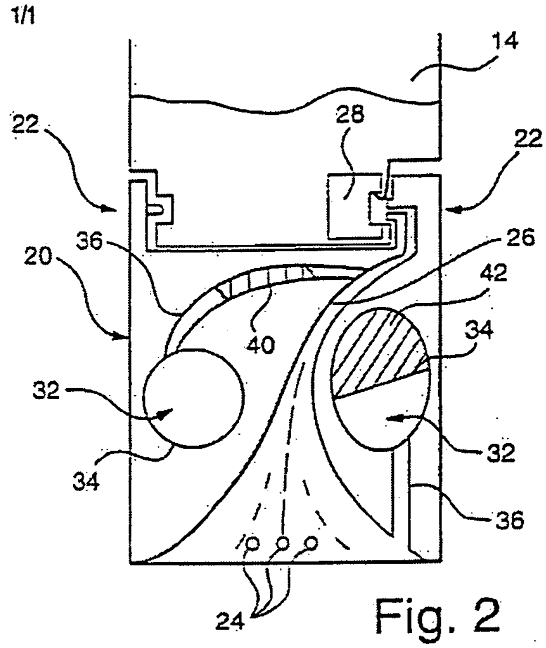

Fig. 2

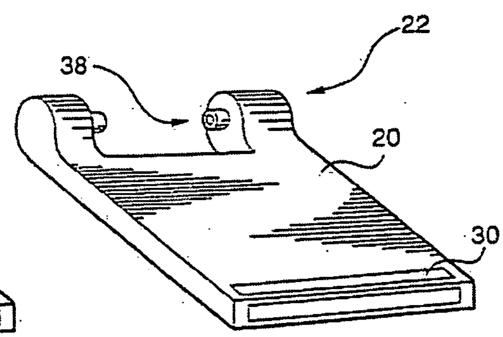

Fig. 3

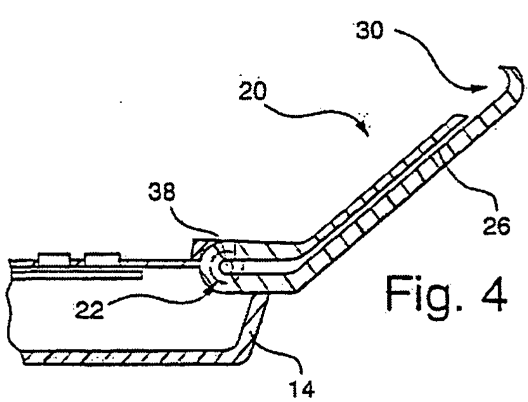

Fig. 4

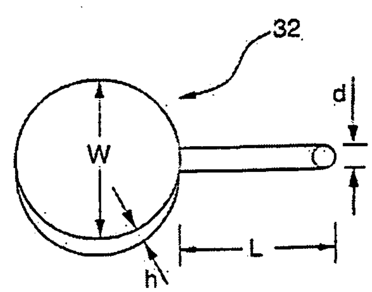

Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/06715

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04R1/30 H04R1/22 H04M1/03

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04R H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y		8-10,13, 14,18

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Y		8-10,13, 14,18

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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18 June 1998	16/07/1998

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/06715

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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